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EDITORIAL

The Food Investigation Board

RECENTLY we commented on the importance of investigations in connexion with the growth of foodstuffs in this country and with the preservation of these foodstuffs and those imported here. The problems are extremely complicated and some of them are so difficult that few private firms could afford the expense of the prolonged research required. It is not always easy to decide what sorts of research should be undertaken by the state and which should be left to private enterprise, but questions involving the health of the community are particularly suited for investigation at the expense of the state, especially if they are urgent questions and involve a prolonged and costly study. The Report of the Food Investigation Board for the year 1932 has just been published and it seems to us to be exactly the sort of report that is required in the circumstances and that the work described in it is excellent work reflecting great credit on all those engaged in it. The Food Investigation Board is a branch of the Department of Scientific and Industrial Research and the director of it, Sir William B. Hardy, F.R.S., is recognized as one of our greatest authorities on this subject. The work that he supervises and assists is carried on in several places: (I) the Low Temperature Research Station at Cambridge of which he himself is the superintendent; here experiments are made on the storage of meat, fruit, and vegetables, on canning, and on corrosion; (II) The Torry Research Station at Aberdeen, the superintendent of which is Mr. A. Lumley; here experiments are made on the freezing and cold storage of fish and on other problems connected with fish; (III) the Ditton Laboratory at East Malling, Kent, of which Dr. C. West is the superintendent; (IV) the National Physical Laboratory where experiments are made on the transfer and flow of heat, on evaporation and such subjects; (V) the Imperial College of Science and Technology where chemical and biological work on fruit is carried on. Of course a good deal of other research quite outside the Department is also carried on, by Messrs. Lyons & Co. for instance, some of which is referred to in this report, and the firms engaged in the manufacture of infant foods, bread, biscuits, chocolate, yeast, and other such things have also very useful and important research organizations the workers in which continue to publish papers of much scientific value. A more complete account of these would be of interest, but at the moment we are only concerned with the state research. The report has about three hundred pages of particularly interesting investigations and it will be read, we have no doubt, by food experts all over the world with profit and satisfaction; we can only comment on a very few of the items referred to. Dr. Moran of Cambridge and Dr. Lampitt of Messrs. J. Lyons & Co. have experimented on the rapid and the slow freezing of meat, and their work, which was carried out in collaboration, showed that the most fastidious experts could detect no difference between meat preserved by these two methods. A complete account of this work is to be published. There is an interesting chapter on the respiration of apples; apples and many other fruits absorb oxygen from the air and produce carbon dioxide long after they are gathered; about a week after they are gathered they produce carbon dioxide at the maximum rate after which the rate steadily declines for several more weeks. Carbon dioxide is apparently not the only vapour given off by apples; a few ripe apples placed among potatoes prevent them from sprouting as they usually do and it seems probable that there is a slight evolution of ethylene having this very singular effect. When a few weeks ago we were writing very unscientifically on the ripening of fruit long after it was gathered, we little suspected that a few days afterwards we should read of careful and very remarkable experiments on this very topic. The vapour given off by apples delays the normal sprouting of potatoes and peas but hastens the ripening of bananas and tomatoes. The vapour of ripe bananas induces the ripening of green bananas; ethylene, propylene, and acetylene are stated to be the only gases known to have this effect upon bananas and tomatoes and it is suspected that ethylene is responsible for the effect of apples on potatoes and peas, but the quantity evolved is too small to be identified up to the present. There is much more of interest in this Report and it is well worth reading.

Cacao

The official bulletin for July of the Office International des Fabricants de Chocolat et de Cacao contains an important paper by Mr. A. W. Knapp, assisted by Messrs. E. Wiehr and L. Olivier, entitled "The Kind of Cacao the Manufacturer Wants." The paper is published in French, English, Spanish, and Portuguese and deals with the varieties of the cacao tree most likely to give a profitable crop, the desirable characteristics of

the beans, the fermentation of the beans, cleaning, packing, transport, and such matters. Most of us are aware that the cacao tree provides us with chocolate and cocoa and it seems a pity that with a powerful international organization of the manufacturers to control the destinies of the industry it possesses such confusing spelling anomalies. Spelling is an obstinate subject to cope with: Hitler can at a moment's notice make profound alterations in politics, religion, and business but so far we think he has not interfered with spelling. Roosevelt can raise the prices of commodities over a very wide area of the world and convert in a few days a hundred million miserable pessimists into exuberant optimists, but if he were to suggest to the Americans that they should make their spelling conform with our far better English usage, he would probably spend the rest of his life behind a set of iron bars. Plenty of worthy people have suggested to us that we could improve our spelling: we permit a great liberty of speech, thought, religion, and other important matters here,—more than they do in all European countries and we allow these reforming enthusiasts to suggest any new spelling they like, confident in the belief that their expenditure of energy will be all in vain. Since reading Mr. Knapp's article on Cacao we have glanced at our standard books of reference in the hope of finding structural formulæ, always grateful and comforting, of those curious substances that give the cacao we convert into our morning cup of cocoa its distinctive colour and its distinctive flavour. So far the information we have found has been vague and unsatisfying, but we have not abandoned all hope.

Theocritus in Essex

It is poverty and dire necessity that compel writers to take infinite pains and put forth their best work. There were two men who made their living by writing and they slept in an old boat moored in a creek of the sea; they were neither young nor old but had long experience with their pens. At low tide the boat lay steadily and securely on the muddy shore of the creek and there were many runnels of water, and much samphire grew on the banks of these, a herb that makes an excellent condiment for meat, and there were beds of purple sea-lavender, and green sea-spinach, and round them the gulls circled with a pleasant screaming cry. At high tide the boat was gently rocked by the incoming waves and the sound of the water lapping against the side of the boat was refreshing to them. At a little distance there were green meadows and pastures and fields of oats; the gentle breeze made a rippling movement of the delicate brown oats but it hardly moved the sturdier wheat that was green and not ripe for cutting. And further away were low hills with immemorial elms, and lime trees beloved by the bees, and sycamores, from whose wood the turners fashion bowls and other household goods, and great gnarled oaks. The creek opened into a broad estuary in which many great steamers were moored, waiting until they could make a profitable voyage to foreign lands. Many months they had waited and it seemed as if they would have to wait many more months. These two men having fried their bacon and boiled their eggs, made themselves ready a drink of tea, and because they were delicate in their taste, they used tea that came from the farthest east, flavoured with the Pekoe tender leaves, and with green tea that slowly ripens and matures. So too the pomegranate plucked green ripens far over the sea and our remembrance of woods, and hills, and of streams hurrying over the stones, and of music and friends grows sweeter as time goes on. And when these two friends had finished their frugal meal and had set out their pipes and their matches and their pens and paper, the one said "Ah! if only I had bought Carreras a few months ago and sold them now, I should have made a small fortune and I would have gone with a few friends to the valley of the Loire and I would have gladly entertained them and given them a holiday; and I would have bought a yacht and sailed to Burnham and Woodbridge and even farther." And the other replied "And if I had bought the shares of Distillers and of Manbré & Garton I should have made much money and I would have bought a Homer published by Foulis, a goodly folio, and I would have carried it home, heavy as it is, and kept it, a book fit for kings; and I would have bought much red wine, from Nuits St. Georges, in Burgundy, and you and all my other friends would have enjoyed it with me." Oh foolish men! cease from dreaming; take up your pens and proceed with the allotted task!

The Chemist in Business

The young chemist, fresh from the University, who obtains an appointment in an industrial concern, often finds himself faced with a number of problems which arise not so much from any lack of scientific training but rather from a scanty knowledge of marketing, finance, and executive control. In a small concern he may find that as a "technical man" he is expected to be able to answer many questions and deal with a variety of matters, and even in the larger industrial concerns work is rarely so specialized as to allow him to be solely a chemist. The gap which exists between the university and business has sometimes been a source of annoyance to employers: it is with much interest that we have noted some commendable endeavours to bridge the gap, and in this issue of the JOURNAL mention will be found of two of them. The London School of Economics established its Department of Business Administration two years ago; the value of the Department's work is already well appreciated by firms in this country, as appointments during the past year bear witness. The Department now proposes to conduct a "University Scheme," by which some well-known firms are offering appointments to selected graduates taking the Department's one-year business course. We find too that the Students Union of the Institute of Industrial Administration has arranged an attractive programme of lectures which will enable students, during the winter months, to hear authoritative statements on many aspects of management. Such schemes are wholly admirable, for by means of them both chemists and the industries which they serve in this country will eventually benefit.

PLASTICS: THEIR USE IN DENTISTRY*

By PROF. C. S. GIBSON, O.B.E., F.R.S.

The use of some form of plastic material as the base on which artificial teeth can be mounted dates back to the time when the possibility of supplying substitutes for natural teeth was first considered feasible. However crude the technique, so long as it was possible to take an impression of the upper and lower jaws and so to construct a model of the mouth it must have been possible to fashion a support on which artificial teeth could be mounted.

Metals, or rather alloys, were the first plastic materials used for the purpose. The making of metallic dentures is now a fine and widely practised art and plastic materials in the form of new alloys of precious metals or stainless steels are constantly being made for the dental profession. The demand for material more readily constructed as a denture base led to the use of non-metallic plastic materials, but it should be borne in mind that, in one respect, metallic dentures accurately fashioned and suitably finished with regard to artistic appearance will always have an important place in dental prosthetics. If, unfortunately, a denture has to be worn, one constructed of material having heat-conducting properties tends to keep the oral tissues sensitive and therefore more healthy than an appliance made of materials whose essential property is that of being bad conductors of heat. The non-absorptive nature and the ease with which metallic alloys can be kept clean and antiseptic are also essential properties inherent in materials which have to be worn more or less continuously in the mouth.

Without minimizing the importance of the use of metals as materials for denture bases, there is a very great and increasing demand for non-metallic plastics, which can be fashioned into denture bases more easily and readily than metallic alloys, and the conditions which such plastic materials must fulfil are:

(i) They must be capable of being moulded accurately to the mouth model;

(ii) Under the conditions of making the denture, the material must flow readily and then harden so as to allow of the artificial teeth becoming firmly attached;

(iii) They must be suitable for the construction of complete and partial dentures having, where necessary, suitable bands or springs according to the dental surgeon's and patient's requirements;

(iv) They should absorb oral fluids to a negligible amount;

(v) They must be capable of being easily cleansed and rendered antiseptic by reagents commonly available for the purpose;

(vi) When converted into the final complete or partial denture they must suffer no deformation under ordinary conditions of cleansing;

(vii) When converted into the final denture bases, they must be and remain under conditions of wear and suitable cleansing in harmony artistically with the mouth tissues.

However enthusiastic one may be concerning the greater use of modern plastics in dental prosthetics it must be acknowledged that from every point of view except those of cost and difficulty of production there is no material at present available which is as suitable as the continuous gum porcelain work on a platinum base. The sufficiently translucent property of porcelain, the fact that it can be coloured at high temperatures with such a chemically stable material as purple of Cassius to simulate any natural gum, its stability under all oral conditions and the ease with which it can be cleansed are all desirable features which need no emphasis. The preparation of such a prosthetic appliance is necessarily very costly, and largely for this reason the art of continuous gum prosthesis in porcelain is not so well known as formerly and is tending, perhaps too rapidly, to disappear.

Celluloid was the first plastic to be used for non-metallic denture bases. This material was rendered opaque with a suitable filling material such as zinc oxide and tinted generally with vermilion. It had the merit of being easily moulded under pressure at a convenient temperature, but had the drawback of being too absorbent of oral fluids and, neglecting its inflammable nature, had a too distinct camphoraceous taste. With the development of the use of vulcanite, celluloid, for a considerable time, fell into disuse as a material for permanent denture bases. During the last few years there has been a revival in its use for this purpose. This revival has been justified as a result of the many improvements in celluloid production consisting amongst others in a substantial reduction of its inflammability and the partial or complete substitution of other suitable materials for the camphor, and, having regard to its use as a prosthetic material, the production of a much more artistic material by the use of suitable filling and colouring materials. For temporary dentures, these celluloid preparations have a recognized place, but if it is possible a reduction in their power of absorption of oral and other fluids is highly desirable. Celluloid preparations are usually supplied to the profession in the form of pressed "blanks," and this preliminary pressing appears to set up permanent strain or strains in the material and at times a tendency has been noticed for the repressed material or denture base to revert to the original first form causing a certain amount of deformation under suitable temperature conditions.

Goodyear's patent (1851) "For improvement in plates for artificial teeth" marked the beginning of an important development of the production of non-metallic denture bases. Goodyear's process consisted in heating the flasked model with the teeth *in situ* packed with a thoroughly impregnated mixture containing 1 part by weight of sulphur with 2 parts of natural rubber or caoutchouc together with suitable colouring material such as vermilion or iron oxide. The colouring substance was mixed with zinc oxide to produce varieties of shade and it was pointed out that "the filling materials must be capable of withstanding the conditions of vulcanization." There is little need to refer to the development of the rubber industry and of our knowledge of the vulcanization process since that time. The present high standard of dental rubber, *i.e.*, the rubber mixture or
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* Lecture given at the Plastics Exhibition, Science Museum, London, S.W. on May 26, 19[illegible]

standardization of the vulcanization process by the use of the dental vulcanizer have made the production of a vulcanite denture almost a routine process which can be carried out rapidly and which requires the minimum of supervision. Apart from its being somewhat bulky and heavy in the mouth, a well-constructed vulcanite denture fulfils in a remarkable manner all the above requirements of an ideal material for a denture base except one, and that is in the matter of its appearance. Apart from its flat and inartistic appearance—and as far as the gum margin is concerned this can be made more artistic by a suitable facing—vulcanite sets a very high standard for any proposed alternative new plastic material to attain. It is, however, this lack of artistic quality in the vulcanite denture base that has rendered necessary the search for new and much more artistic plastic materials which can be applied to the making of denture bases since it appears to be impossible to obtain a translucent vulcanite.

It is, however, useful to consider certain points in connexion with vulcanite as a denture base so as to have the necessary perspective concerning the utilization of new plastics for this purpose :

(i) The conversion of rubber into vulcanite is an irreversible chemical change, so that the final physical form is permanent in all conditions to which the denture is liable to be subject in normal usage ;

(ii) As a result of many years' experience and patient investigation, much of it by dental surgeons themselves, the technique of making a vulcanite denture is simple, the necessary equipment small and inexpensive, and the operations can be carried out easily in any ordinary prosthetic laboratory.

(iii) The repairing of a vulcanite denture, when necessary and advisable, is also comparatively easy.

(iv) A vulcanite denture will withstand a not inconsiderable amount of what may be termed "abusive" treatment which it sometimes has to undergo in spite of the fact that a denture is only meant to be worn in the mouth and is a very valuable, but essentially personal, aid to health and normal facial appearance.

(v) Although its appearance is flat and inartistic, the whole material of a vulcanite denture base has a very high degree of chemical stability, so that, coupled with its being almost non-absorptive to oral fluids etc., it is extremely easy to keep clean and in its original condition.

Of the modern non-metallic plastic materials then available which might be suitable as an alternative to vulcanite for the making of denture bases, it appeared that synthetic resins of the phenol-formaldehyde class might be usefully explored. In 1924 the Dental Investigation Committee of the Department of Scientific and Industrial Research, by means of funds provided by the Dental Board of the United Kingdom, inaugurated an investigation in the Chemistry Department of Guy's Hospital Medical and Dental Schools. The work was entrusted to Dr. E. E. Walker (now of the Research Staff of British Dyestuffs Corporation, Imperial Chemical Industries, Ltd.) who showed that the condensation of phenol with formaldehyde in the presence of alkaline condensing agents when allowed to proceed to a stage short of precipitation of the resin and the resin precipitated by means of acid gives a light coloured "resinoid" which can be incorporated with suitable filling and colouring materials. This resinoid or plastic resin he further showed could be packed into the suitably prepared model as in the case of the packing of dental rubber but with suitable modifications and converted by heating into the final material of the denture base having great mechanical strength and sufficient chemical inertness (E.P. 259,046 of 1925 ; Walker, Fry, and Gibson, British Dental Journal, 1927, **48**, 1013 ; Fry, "Non-Metallic Denture Bases," Lectures of the Dental Board of the United Kingdom, 1931, p. 53). This material is now manufactured under licence from the Department of Scientific and Industrial Research by the Dental Manufacturing Company, Ltd., under the name of "Walkerite." As a result of further and continuous investigation, the Dental Manufacturing Company has modified the original process in detail and now produces for the profession a plastic resin which, when worked up in the prescribed manner, is converted into denture bases, specimens of which are shown with other exhibits which have been prepared for this exhibition under the direction of my colleague, Dr. Ernest Matthews, L.D.S., R.C.S. (Eng.) of Guy's Hospital Medical and Dental Schools, who has the unique qualifications of chemist and dental surgeon.

The chemical changes taking place in transforming th resinoid or plastic resin into the final resin are, like th vulcanization process, irreversible, and consequently like vulcanite, the physical form of "Walkerite" i permanent under all conditions to which the dentur may be subjected in ordinary usage and treatment Considerable practical experience has proved the suit ability of phenol-formaldehyde resins such as that now described as highly suitable materials for denture bases This particular material is incorporated in the resinoi or plastic resin stage with materials which are resistan not only to the conditions of completion of the resi but also to oral and suitably cleansing conditions jus as the filling and colouring materials of dental rubbe and vulcanite. Such phenol-formaldehyde resins hav absorptive power little greater than that of vulcanit and are kept clean and antiseptic just as easily Although the technique of making such a phenol formaldehyde resin requires care, the artistic nature o the finished denture more than compensates for this eve when partly translated into the extra cost involved.

Other types of synthetic resins may be successfull applied to the production of denture bases. Any of thes which can be rendered sufficiently semi-liquid and s moulded at a convenient temperature and under pressur without chemical change can be used in a somewha similar manner to celluloid. For example, certain o the vinyl resins belong to this class and yield highl artistic materials. It only needs to be emphasized tha any plastic for use as a denture base requires to b absolutely chemically stable under oral and suitabl cleansing conditions. The minimum absorptive capacit is necessary and any material which softens at a tem perature much below 100° C. may become deforme under cleansing conditions.

Although the actual amount of any plastics utilized fo denture bases may not be considered large industrially I should plead the importance of their increased investi

..n for this purpose from the point of view of national ..h. I would also emphasize the importance of close- ..peration with members of the dental profession in .. investigations and finally repeat the necessity of ..ng in mind that any new plastic must, apart from ..ppearance, approximate in chemical stability and .. of conversion into the final denture to the well-tried ..anite.

PLASTICS: THE PHENOLIC TYPE AND THEIR USES*

By GEORGE DRING, M.A., B.Sc.

The best thing I can do this afternoon is to give you .. simply and as straightforwardly as I can an outline .. the manufacture, uses, and development of phenol ..sinoids over the past 25 years, and I will endeavour .. give you some idea of their possibilities in the near future, although the full extent of the field they will ultimately occupy in the mechanical, electrical, and decorative industries is difficult to forecast.

Every organic chemist knows how annoying it is when he is trying to prepare a nicely-crystalline body which he can characterize with a well-defined melting point to find that all he is able to prepare is a nasty, messy material which he usually throws away down the sink as a resinous or tarry mass. Ordinarily such misfortunes are confined to the test tube or the flask in the laboratory; but in the industry with which we are concerned such tars or resinous matters are made deliberately and under controlled conditions, and are made by the ton and used as a raw material for the manufacture of various types of articles. There are many different raw materials that can be used to give these resinous bodies, which are themselves the raw materials of the plastics industry, but the ones with which we are concerned are those made by the condensation of phenols and formaldehyde.

Phenol-formaldehyde resins may be made not only with crystalline phenol C_6H_5OH but with cresols, xylenols, and other homolognes of phenol; but in regard to the other components we can confine our attention to the simple aldehyde formaldehyde or its polymers, such as para-formaldehyde, or compounds of formaldehyde with bases, such as hexamethylenetetramine.

Some of you may be interested in the various theories that have been put forward as to the formulation (one can hardly call it a formula) of the phenol-formaldehyde resins but I do not propose to deal with these and would suggest that those who wish to know a little more about the purely chemical aspect of the reaction should make a start with the summary given by Baekeland and Bender in *Industrial and Engineering Chemistry*, Vol. 17, No. 3 (1925), p. 225. A very full list of abstracts has been prepared by the Science Museum Library covering the whole field of references to the literature of plastics and can be obtained for the price of 5s.

I want to give you a simple outline of the actual manufacture of a straightforward phenol-formaldehyde resin. Here is some commercial phenol, a white crystalline body, which is obtained from the distillation of coal tar. Its melting point is 40—41° C. The solution you see here contains 40% of formaldehyde dissolved in water. Formaldehyde is a gas which is prepared from methyl alcohol by dehydrogenating it over a nickel catalyst, methyl alcohol itself being obtained by the dry distillation of wood. Actually formaldehyde is rather liable to polymerize into para-formaldehyde and throw itself out of solution, para-formaldehyde being a not very soluble solid; but a certain amount of methyl alcohol is usually left in the solution to prevent such polymerization occurring.

When phenol and formaldehyde are mixed together, they give a water-white liquid and if this solution were boiled for several days we could probably get a reaction, but in order to get the reaction to occur in as short a time as possible and to produce the greatest possible output for a given size of plant, or to make some particular type of resin, we add a catalyst. The catalyst may be chosen in particular from various acids or bases, although, in fact, I think it would be right to say that there are patents covering the addition to this reaction of a large part of the raw materials appearing in the chemical dictionary. The resins which are made using various catalysts do vary in their properties but I do not propose to spend much time on a specialized discussion of the variations which can occur by the use of various catalysts under different conditions of temperature, pressure, and time.

For the majority of resins one molecular proportion (94 lb.) of phenol is reacted with rather less than one molecular proportion of formaldehyde (75 lb.) although for special purposes, such as light-coloured hardened resins, two or more molecular proportions of formaldehyde are used. The phenol, formaldehyde, and catalyst are boiled up together in steam-jacketed pans to bring about the first stage of the condensation reaction. When that reaction is over the material will separate into two layers, a watery layer on the top which is useless and below that a treacly mass which is dehydrated by heating it at either atmospheric pressure or under vacuum until it reaches a stage where, on cooling, it solidifies to a hard brittle resin—Resin A as it is called. Now the whole of this lecture, the whole of the Exhibition upstairs, and an understanding of the whole of the plastics industry will be quite lost on you unless you clearly appreciate the remarkable properties of this particular resin. I have a small piece in this test tube; by gently warming it over the flame it melts, it flows, but all the time I am heating it there is a further reaction going on. The resin is polymerizing, more and more complex molecules are being formed, and it is becoming increasingly apparent that the stage of complexity of a resin is as important as the melting point of a crystalline body and if we are ever able to measure the molecular complexity by some means as we can measure melting point we may perhaps be able to forecast the possibilities of a special resin for a special use.

In the case of phenol-formaldehyde resins this polymerization which is going on under heat is irreversible. Perhaps that is not strictly accurate, because to a

* Lecture given at the Plastics Exhibition, Science Museum, London, S.W. on June 7, 1933.

certain extent you can break the polymerized resin down again under very stringent conditions, but to all intents and purposes that polmerization under heat is irreversible. There are some other resins which are called thermoplastic, which are *not* heat-hardening, but we are not dealing with these and the special characteristic of the phenol-formaldehyde resins which they now share with one or two other more recently developed synthetic resins is that they harden on heating.

I have now hardened this resin. It looks a frothy, useless sort of mass, but you will see that it is quite hard hard and insoluble in practically all solvents, although it is slightly acted on by strong caustic alkalis, also to a minor extent it is attacked by other materials acting for a long time under stringent conditions, but for all general purposes the material can be said to be practically inert to chemical attack and a non-conductor of both heat and electricity. That frothing can be prevented if the heating is carried out under pressure. Here you have a clear transparent piece of resin which has been hardened under heat and pressure. A resin of this type can be used for the manufacture of artificial jewellery, bracelets, cigarette tubes, and for other similar purposes. It can be machined easily and many tons of ornamental and useful articles have been made in this way.

The discovery of the way in which this resin can be hardened under heat and pressure and tamed to industrial uses is the great gift of Dr. Baekeland to the plastics industry.

The largest use for phenol formaldehyde resins to-day is in the manufacture of moulding powders which are merely mixtures of resins with various fillers. There are two main methods of manufacturing moulding powders. This first initial Resin A will dissolve in alcohol or methylated spirit giving a thick viscous solution which can be incorporated or mixed in with various filler materials in a mixing machine or dough mixer to give a sort of moist dough. The most commonly used filler is woodflour, which is cheap and can be obtained in large quantity of a regular degree of fineness and purity: but it is not used because of its cheapness alone—for whatever price one would be prepared to pay for a filling material there is no other material which gives the same combination of good properties as woodflour. Most fillers introduce some little difficulty all their own, but these difficulties are of interest solely to the moulding powder manufacturer.

The woodflour, wetted out with varnish together with the other ingredients which go to make a perfect moulding powder, is spread on trays and dried in a vacuum oven at low temperature in order to remove the spirit solvent. We thus have the woodflour filler intimately incorporated with resin, dyed to whatever colour we like, and dried to such a stage that the moulding powder is now ready for the moulder. This is the wet method of manufacturing moulding powders. What is known as the dry method can also be used. In this case the resin is ground up finely in a grinder or ball mill and then intimately mixed in the dry state with the filler, pigment or dyestuffs, lubricants, and so forth. These dry materials, intimately mixed, are then compounded together in the same manner and in very similar machinery to that used in the rubber industry for com pounding rubber. The Bridge Banbury mixer is jus a steam jacketed mixer with rotating interlocking blades or the material can be passed repeatedly through heate rollers until the whole material is sheeted together The action here is that the resin melts under the appli cation of heat and the melted resin itself is sufficientl fluid to impregnate the whole of the filler, so that agai one obtains substantially an intimate mixture of resi and filler.

The moulding powder manufacturer has now finishe his share of the work and the moulding powder is read for the moulder. At one time it was quite sufficien for the moulding powder manufacturer just to make moulding powder and sell it. Nowadays mouldin powder is subjected to as much controlled analysis an controlled testing as any pure chemical could be. Fror start to finish of its manufacture, from the very ra materials themselves through every intermediate stag chemical and physical control is exercised and furthe accuracy of control is being worked out year by yea so that it is now possible to turn out ton after ton material to stated characteristics, and if any deviati can be found it is immediately the subject of resear and development to find some method of characte izing and controlling that particular difficulty.

The moulder has become a wonderful craftsman i the course of the past few years. In the Plastics E hibition there is an hydraulic press with heated platen The moulder opens the press, puts in a weighed measured quantity of moulding powder and the immediately closes the press; the resin begins t melt and the whole material fluxes and while in th fluxed state it is pressed into every corner of the moul At the same time under the action of heat the materi is polymerized. The temperature is around 300° F to 350° F. and the pressure approximately 1 ton p square inch; and in one, two, or three minutes, accordin to the size of the mould and the thickness of the sectio of the moulding, the moulding powder has complete hardened and the article is a finished moulding. Th press is opened and the article is taken from the moul giving exactly the same shape as the steel mould and wit the same bright polished finish as is on the mould itsel Only slight flash lines, the gap between the top an bottom forces, remain to be cleaned off. The surfac has no need to be buffed or otherwise interfered with.

It is all very simple but when one considers some the complicated moulds which have been moulde when one sees whole batteries of semi-automatic mult impression moulds turning out mouldings at the rate thousands per hour, complete with threads and met inserts, it really seems inconceivable that it is done wit material starting from these two liquids which I hav shown you. For those who appreciate the moulder' art, some of the smallest of mouldings are the mos interesting and amazing. The selection of moulding shown at the Exhibition in all their beauty of colour an shape is an ever-recurrent surprise even to those wh are in daily contact with this industry.

A practical moulder could entertain you for hours o various methods of moulding, on all the difficulties h has met with and overcome, of various little wrinkle

ıt he has learned in the course of his experience with ›ulding materials. He would discourse of positive, ni-positive, flash type, and automatic moulds. He uld be interested in the question of whether the powder be used was suitable for pelleting or preforming so ıt he could use compact tablets or preforms of mould- . material of fixed weight and size instead of weighing · quantities of loose powder. He would speak of heating the powder or pellets before loading the ould and he would show how important are the ›tions of the contraction in the size of the moulding n cools down after being ejected from the hot mould. ese points are all of first importance from the point view of both the moulding powder manufacturer and · moulder but they are rather questions of technical ail which we must regard as being outside the scope this lecture.

Before leaving the subject of moulding powders, a few ther points on the actual types of resins used in the inufacture of moulding powders and the question of rious types of fillers may be of general interest. In › first place a distinction must be drawn between a e-stage moulding powder and a two-stage moulding wder, and something further can be said of the ference between a resin made from phenol, cresols, d xylenols. To explain the difference between one d two-stage moulding powders, we must go back to e first stage of resin formation. A resin made with basic catalyst on the application of further heat simply es forward on its own through the condensation stage the polymerization stage and never stops until it iches its final finished condition—that is, it is a one- ge resin. But if one uses an acid catalyst instead a basic catalyst in the first reaction the resin formation es to the condensation stage and then ceases. It ll only polymerize to the final "C" stage by the dition of further methylene groups in the presence of alkaline reagent—the second stage of a two-stage action.

Most moulding powders are now made on two-step es. The resin which is used in their manufacture is acid-catalysed non-hardening or Novolac resin, and the actual mixing operation in either wet manufacture dry manufacture a further amount of formaldehyde the form of hexamethylenetetramine is added, and by e application of heat in the mould a fully-hardened sin or a fully-hardened moulding is formed. It is not rtain that one-step moulding powders entirely deserve eir ill reputation. In the past one-step moulding wders have been reviled because of their odour and eir slow moulding qualities, and because they ejected om the mould in a flabby condition. Against this ey could be made to give exceedingly good electrical operties and were cheap. Nevertheless they have d to take a second place alongside the speedier, more ourless, and harder moulding two-step materials; hough with still better understanding of the actual ethods of resin manufacture the one-step resins may t regain a place in the plastic field.

Speaking for a few moments in regard to phenol, esols, and xylenols, it is remarkable that the first of e series is so uniquely desirable in the phenol-formal- hyde reaction. One would almost think that the greater complexity of the higher phenols would result in a moulding material of higher qualities than that from the simple phenol, but this is not borne out in practice. There are, of course, the added difficulties that in commercial quantities the higher phenols are far from pure. But it is a matter of prime economic importance to find some way of manufacturing from the homologues of phenol a resinous material as valuable as can be manufactured from phenol itself. Obviously it is a wasteful and unbalanced industry which takes from coal tar only one ingredient and uses this to the exclusion of the other components of tar acids. Luckily there is a certain amount of use, apart from the resin industry, for these other tar acids, but these do not balance the growing demand for pure phenol for resin manufacture. A lot of work has been done, is being done, and will be done to manufacture from the homologues of phenol a resin as useful as from phenol itself, and it is not impossible that with our growing knowledge this can be done with every hope of success. There is one remarkable phenol, resorcinol, which has given promise of producing an extraordinary material, but so far it has not justified the high hopes that were held of it some two or three years ago. It gives an exceedingly rapid moulding powder which appears to make it extremely desirable for moulding purposes but unfortunately it is rather too rapid for our present-day conception of moulding. At the same time its price is somewhat against it, but if it were possible to manufacture it at a lower price it is quite likely that further work would be done to bring it into subjection and to make it a valuable adjunct of the resin manufacturer. The field of available phenols is being more and more fully explored. There are many gaps in the list of possible phenols and it is possible that some may yet be discovered which will give us a far more valuable resinoid than we have at the present time.

In the description which I gave earlier of the manufacture of moulding powders, I took woodflour as the typical filling material and said that this material is the one most largely used, but there are a number of other fillers which are used for special purposes and many of these have been covered by specific patent applications, as they are generally used in order to provide a moulding powder with some particular property. For instance, asbestos fillers give heat-resistant moulding powders which are used for such purposes as heater plugs and ash trays. If short-fibred asbestos or asbestos floats are used, the finish is extremely good, but the mouldings are rather fragile. Long-fibred asbestos can be used where greater strength is required but the fibres usually show on the surface and detract from the appearance of the moulded article. Mica is used to give low-power factor and high-water resistance. Fabric materials of various kinds are used in the manufacture of materials having a high-impact strength and by their use moulding powders can be prepared which have an impact strength more than 10 times that of wood-filled mixtures.

So far I have dealt with the production of resins and moulding powders made from them. In discussing the wet process of making moulding powder I referred to the preparation of spirit varnishes by dissolving resin in

methylated spirit but generally in making one-step varnishes for coating purposes and for the manufacture of laminated materials, the spirit is added directly to the still while the resin is still warm and fluid to give a varnish of certain controlled qualities of specific gravity or viscosity. In some measure the manufacture of synthetic resin varnishes can be considered rather as an art than as a science, but these varnishes are now being more and more accurately controlled for the special purposes for which they are required. In all the uses to which these spirit varnishes are put the solvent is driven off by heat under various conditions and then the final resin film is hardened to the insoluble, infusible stage. These varnishes are used as baking varnishes for protective purposes and for such other purposes as the impregnation of coil windings where the function of the solvent, with or without other plasticizers, is to carry the resin right into the coils to impregnate the windings after which the solvent is driven off and the resin thoroughly hardened out, so giving a coil which is completely immersed in a solid, insulating block of synthetic resin material.

One of the largest uses for spirit varnishes is in the manufacture of laminated materials, and for this purpose cresol varnishes are used almost exclusively. As ordinarily carried out this process consists in taking a roll of filler material, whether it be in the form of paper, fabric, or asbestos sheet, passing it through a bath of varnish and then through a drying chamber heated to a definite temperature in order to drive off the solvents, and the dried material is rolled up at the end of the machine. The paper, fabric, or asbestos may be either surface-coated or fully impregnated with varnish according to the type of material required, and after passing through the oven and removing the solvents the resin in or on the filler material is in that same stage of condensation as the resin which we have already met with in a moulding powder. The impregnated or coated filler is then cut up into sheets of certain size which are laid one above the other into a pile and pressed between metal sheets in a large press at a pressure of 1 ton per sq. in. and at a temperature of around 130° C. In order to get the best quality of laminated sheet it is essential that there should be plenty of time for the heat to get through the whole of the pack of laminæ before complete hardening takes place, and after polymerization has taken place the whole press load must be cooled down by passing cold water through the platens. The size of the sheets depends on the size of the press, the sheets I have personally handled being 3 ft. by 3½ ft. and 3 ft. by 7 ft. The thickness of the sheets may be anything from five-thousandths of an inch to 5 in. and depending on the thickness of the sheet the pack of laminated material may be in the press for 4 to 5 hours including the time of heating up and cooling down.

The original use of laminated sheet with paper filler was for electrical insulation purposes, and for some particular uses it is almost an ideal material. It has been used in large quantities for insulating parts which are punched out of sheet and used in various applications in the wireless industry and in the telephone industry. Most of the thinner material can be made to punch well and special grades of material are available which will punch perfectly in the cold. Fabric laminated materials are very strong and are used very extensively for the manufacture of gears and bearings which are silent in running, have very long life and do not soften in the way that raw hide gears are liable to do. As in the case of moulding powders, an asbestos filler is used to give the highest heat resistance and by special treatment such materials can be made to be extremely fire resistant. By the use of special varnishes, caustic resistant laminated for moulding into trays for domestic use, and odourless laminated for use in refrigerators can be made. The present tendency is to use these laminated materials more and more for mechanical and structural purposes. New types of applications are shown in the Exhibition, where laminated materials are used for wall panelling, doors, table tops, and although the requirements for this type of use have not entirely been worked out this application is extending and laminated materials will undoubtedly take their place in the decorative industries and in the manufacture of furniture. New surface finishes are being worked out and colours which are permanent to light and surfaces which will resist the hardest wear are in process of development.

So far my remarks have been confined entirely to sheet laminated but you will readily understand that tube and rod can be made in very similar fashion. The impregnated or coated filler is heated over a roller and wrapped in a continuous fashion around a mandrel under pressure from the weight of the mandrel. A whole tube is thus formed with the mandrel as the core and the wound tube is stoved to completely harden the resin. Tubes of all sizes can be made in this way and in a similar fashion condenser bushings can be made, interleaved with suitable metal foiling. To make moulded rod a very small mandrel is used, the small mandrel is removed and the rod is put into a mould and moulded under pressure so that the narrow hole where the mandrel was collapses to give a solid rod.

I have dealt only with the main uses of phenol-formaldehyde resins. There are many hundreds of applications which I could name where particular uses have been found for small quantities of this material. Some of these uses have become very important but are of rather narrow interest. Lamp capping cements, grinding wheel resins, enamel coatings for filling porous castings, hard resistant lacquers for protective coatings in varied industries are just a few of the applications I might mention. A rather unique application which has received considerable publicity quite recently has been the development of creaseless fabrics, and it is clear that the use of resinous materials in the textile industry is only just beginning.

At the present day no account of the phenol-formaldehyde group of plastics would be complete without reference to the newly-developed resins which are of themselves completely soluble in drying oils. It was the search for a resin which would take the place of shellac which gave rise to the phenol-formaldehyde resins as we know them to-day and the resins then made were not soluble in oils but were only soluble in spirit solvents. In course of time it was found possible to make use of the resistence of phenol-formaldehyde resins to a certain extent in oil varnishes by using them in the presence of

ural resin as a mutual solvent. The paint and nish trade has found such modified resins of great ue in the past but it has now been found possible to duce an all-phenolic resin which is 100% soluble in ing oils without any other additions. A large nber of these oil soluble resins are now on the market i there is no doubt whatever that some will find a manent and important place in the manufacture of nts and varnishes and that still further improved ins will be discovered.

'rom what has been said this afternoon and from at you can see in the unique display brought together he Exhibition it is obvious that the phenol-formalde-le resins touch upon practically every industry in country. The practice of resin manufacture and the s of resins have far outstripped the present purely mical knowledge of these synthetic materials. The ne is true of other industries such as the rubber indus- and the paint industry where highly complex emical substances are used extensively in industrial rk and the theoretical knowledge of the substances olved lags many years behind. It is the same with lulose and wood and textiles. One cannot blame the lustrial research and development laboratories for ing unable to solve the complicated chemical and ysical problems involved for they have all they can and more to keep pace with the advancing industry. ie purely chemical aspects of these complex and eresting colloidal problems can be commended to the tention of academic research workers as an almost gin field. Staudinger's recent work is inspiring and allenging and I look forward to the day when the nthetic resins will be made to reveal their resinous crets and I feel certain from the comparatively little at we know even now concerning these materials that ey will offer a field of scientific investigation as fascin-ing as the present field is found to be by those who are gaged in it. Perhaps we shall see the formation of a astics Research Association taking its honoured place th the research associations of older industries under e Department of Scientific and Industrial Research.

PLASTICS AND THEIR GENESIS*

By PROF. G. T. MORGAN, D.Sc., F.R.S.

Any general discussion of the genesis of plastic aterials covers a field too wide to be dealt with in one cture and accordingly I intend to make a selection of e permissible topics. The title suggests first a reference such raw materials as coal, wood, milk, and fat, these ing starting points in the production of many syn-etic and natural plastics, and secondly to numerous termediates such as formaldehyde, urea, thiourea, and r acids which enter into the composition of various pical resins.

I propose to limit this lecture to synthetic plastics, id in particular to that branch included within the term nthetic resins. Furthermore, since the most important these resins have already received ample treatment in eceding lectures, it will be sufficient to outline only briefly the manufacture of certain industrial resins, reserving more detailed treatment for those products which have received particular attention in researches carried out at the Chemical Research Laboratory, Teddington.

It should be understood that while certain synthetic resins have properties akin to those of natural resins, their chemical compositions may be widely different. For instance, the fusible phenol-formaldehyde resins of Novolak type are utilizable in a similar way to shellac in the production of spirit soluble varnishes, but although these two types are alike in function they are quite dissimilar in their chemical natures.

Broadly speaking, synthetic resins may be classified into three main groups, following a scheme arranged by R. H. Kienle (Ind. Eng. Chem., 1930, **22**, 590):

I. *Heat-convertible resins* wherein application of heat leads to completely infusible and insoluble products, the chemical changes involved being irreversible. Phenol-formaldehyde resins of bakelite type, urea-formaldehyde resins and certain polymerization resins of the olefinic and vinyl series are examples of this Group.

II. *Heat non-convertible resins* in which application of heat causes little or no change in solubility or fusibility as illustrated by phenol-formaldehyde resins of the Novolak type.

III. *Element-convertible resins.*—A miscellaneous group in which development of the insoluble resin is brought about by the intervention of an extraneous element such as oxygen. Resins of the glycerol poly-unsaturated ester type are affected by oxygen much as this element oxidizes drying oils.

At the present time plastics corresponding with groups I and II are the most important and the resins subsequently mentioned in this lecture fall into one or other of these two categories.

Formaldehyde: An intermediate in resin formation.—It will have been gathered from previous lectures that formaldehyde plays an essential part in the production of many diverse synthetic resins, and a short account of its manufacture may not be out of place. This aldehyde is produced by dehydrogenation or oxidation of methyl alcohol (methanol) in presence of a catalyst such as metallic copper or platinum. The starting material, methyl alcohol, may be derived either from fractionation of crude wood spirit obtained by distillation of wood, or from high pressure synthesis.

In the second method, which is serviceable in those countries where coal is more plentiful than wood, carbon monoxide and hydrogen (conveniently obtained in the form of producer gas) are passed at high temperatures (450°) and under pressures of 200 atmospheres over a suitable catalyst, such as basic zinc chromate, when methyl alcohol is produced as the main reaction product.

The zinc chromate becomes reduced to zinc chromite and 99% of the reacting carbon monoxide is converted readily into methyl alcohol, which is generally accompanied by a small proportion of higher primary alcohols (propyl, *n*-butyl, and *iso*butyl alcohols with diminishing amounts of higher alcohols).

Formaldehyde itself is a gas which dissolves readily in water so that it generally occurs in commerce as the

* Lecture given at the Plastics Exhibition, Science Museum, ondon, S.W., on July 19, 1933.

40% solution known as formalin. Occasionally it is sold in the form of solid paraformaldehyde, a polymeric modification, or in combination with ammonia as the colourless crystalline hexamethylene tetramine $(CH_2)_6N_4$ also known as hexamine, hexa, or H.M.T.

Urea-formaldehyde resins.—An important resin is produced by condensing formaldehyde with the relatively simple substance urea or carbamide. This substance is of peculiar interest in that it was the first product of vital activity to be prepared artificially without the intervention of any living organism. In 1828 Wöhler produced urea by heating ammonium *iso*cyanate, thereby bridging the gulf which was then assumed to exist between inorganic and organic materials.

Urea is a colourless crystalline substance having the molecular formula $CO(NH_2)_2$: it can be prepared in the following ways: (*a*) By condensation of phosgene with ammonia, a reaction which indicates its chemical structure:

$$COCl_2 + 4NH_3 \rightarrow CO(NH_2)_2 + 2NH_4Cl$$

(*b*) From calcium cyanamide, which is an important intermediate product obtained during the preparation of calcium cyanide from the carbide:

$$\underset{\text{Calcium carbide}}{CaC_2} + N_2 \rightarrow \underset{\text{Calcium cyanamide}}{NC{\cdot}NCa} + C$$

$$\underset{\text{Cyanamide}}{NH_2{\cdot}CN} + H_2O \rightarrow \underset{\text{Urea}}{CO(NH_2)_2}$$

(*c*) By condensation of ammonia and carbon dioxide, or by dehydrating ammonium carbonate both under high pressure.

$$2NH_3 + CO_2 \rightarrow CO(NH_2)_2 + H_2O$$
$$CO(ONH_4)_2 \rightarrow CO(NH_2)_2 + 2H_2O$$

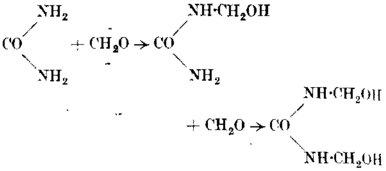
Enormous quantities of urea are now produced by these high pressure processes from carbon dioxide and synthetic ammonia, itself a product of the direct combination of nitrogen and hydrogen under high pressure and in presence of a suitable catalyst. The resulting urea finds extensive use as a fertilizer in agriculture.

Closely related to urea is its sulphur analogue, thiourea or thiocarbamide, of formula $CS(NH_2)_2$, which is a colourless crystalline compound obtained by heating ammonium *iso*thiocyanate. The method recalls Wöhler's original synthesis of urea for it involves a molecular rearrangement of similar type which takes place according to the following equation:

$$\underset{\text{Ammonium } iso\text{-thiocyanate}}{NH_4{\cdot}CNS} \rightleftharpoons \underset{\text{Thiourea}}{CS(NH_2)_2}$$

When either of these compounds or a mixture of the two is heated with formaldehyde in presence of alkali, a water-soluble syrup is obtained which on heating is transformed first into a rubber-like intermediate product and finally into a hard infusible resin of Group I type. The water-soluble syrup is a complex mixture containing considerable quantities of crystalline intermediates including mono- and di-methylol ureas resulting from the direct addition of formaldehyde to urea or thiourea.

These syrups when heated alone under pressure yield almost colourless transparent or opalescent mouldings, but owing to technical difficulties it is usual to add fillers such as paper pulp, whereby white opaque mouldings may be readily produced. Such mouldings have the advantage of being so pale in colour that they may be easily tinted to any desired shade, so that a wide



range of coloured moulded products is available from the urea and thiourea resins. The well-known nonfragile domestic ware is prepared from this type of plastic, while a more recent development is the production of laminated sheet for decorative panelling.

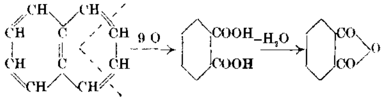
Glycerol-phthalic anhydride resins (*glyptals*).—When glycerin is heated with polybasic acids or their anhydrides, pale coloured resins are formed, known as "glyptal" resins.

Glycerin is an important by-product of the soap industry, arising from saponification of fats such as stearin, which is the glyceride of stearic acid.

$$\begin{array}{llll} C_{17}H_{35}{\cdot}CO{\cdot}O{\cdot}CH_2 & H{\cdot}OH & CH_2OH & \\ C_{17}H_{35}{\cdot}CO{\cdot}O{\cdot}CH + & H{\cdot}OH \rightarrow & CHOH + & 3C_{17}H_{35}{\cdot}COOH \\ C_{17}H_{35}{\cdot}CO{\cdot}O{\cdot}CH_2 & H{\cdot}OH & CH_2OH & \\ \text{Stearin} & & \text{Glycerin} & \text{Stearic acid.} \end{array}$$

Glycerin is a viscous sweet liquid which considered chemically is a trihydric alcohol, whence its scientific name of glycerol.

One of the cheapest polybasic acids on the market is phthalic acid, usually sold in the form of its anhydride. It is produced by oxidation of the important coal-tar product, naphthalene, according to the following diagram:



Naphthalene Phthalic acid Phthalic anhydride

After purification by sublimation, phthalic anhydride is obtained in long well-defined colourless needles.

For the production of resins, phthalic anhydride and glycerol are heated at about 180—200° C. for several hours when water is eliminated and on cooling a colourless syrup or solid remains. Although this product belongs to Group I it is transformed only slowly into the insoluble and infusible form by heat-treatment, and is therefore not used extensively for moulding purposes. It is, however, a valuable medium for bonding mica in the production of panels for electrical insulation,

finds extensive application as a varnish and lacquer medient, as an impregnating resin, and as a constituent of high-grade cements and adhesives. Glyptal resin is considerably more elastic and less brittle than phenol-formaldehyde products of bakelite type. These properties of glyptal may be radically modified by the substitution of alcohols of glycol type for glycerol, and by replacing phthalic anhydride by succinic, maleic, stearic, or benzoic acids. Moreover, drying oils and natural resins may be introduced during or after condensation. These modifications confer on the modified glyptals increased solubility in linseed and similar drying oils.

An interesting extension developed at the Chemical Research Laboratory consists in condensing phthalic anhydride and glycerol in the presence of phenol and paraformaldehyde. Hard pale-coloured highly elastic resins are produced which are utilizable as varnishes. After mixing with more paraformaldehyde, these resins may be moulded and used in the preparation of laminated boards having good electrical properties.

Phenol-formaldehyde resins.—Although the interaction of phenols and formaldehyde has long been known to furnish resinous products, it was not until 1908 that the products became industrial possibilities. In that year Dr L. H. Baekeland filed his important patents, with the result that phenol-formaldehyde resins were developed so rapidly as to become the most widely used and best known of all synthetic resins.

Phenols form a class of hydroxy-aromatic compounds, of which phenol itself (carbolic acid) is the simplest member. They are obtained by extraction of coal-tar fractions with aqueous caustic soda, followed by precipitation with acid and subsequent fractional distillation. The commonest phenols so obtained are phenol, *o*-, *m*-, and *p*-cresols and certain xylenols. For the manufacture of resins, phenol and the mixture of three cresols known as cresylic acid are most frequently employed. The cresylic acid generally contains about 40% of the *m*-isomeride.

When heated with formalin at moderate temperatures, a phenol may yield resinous products of either Novolak or bakelite type depending on the conditions under which this condensation is conducted.

When the reagents condense together in presence of acid, Novolak resins are produced which are unchanged by further heating, always remaining soluble and fusible. These resins, which belong to Group II, find limited application as substitutes for shellac in varnishes. During their formation small quantities of crystalline compounds of dihydroxydiphenylmethane type may be isolated, and as the chemical structure of these crystalline intermediates is known, their production throws light on the mechanism of resinification, at least in its early stages.

Resins of bakelite type belonging to Group I result when the same ingredients are heated in presence of a small amount of alkali; they become infusible and insoluble when heated under pressure. Advantage is taken of this property in the plastics industries to produce an extremely wide range of moulded articles and laminated materials. The crystalline intermediates arising during alkaline condensation are of the hydroxybenzyl alcohol type.

One objective of the resin investigation at the Chemical Research Laboratory at Teddington has been the preparation of products of high dielectric strength. I now propose to summarize certain of these results in order to show how work of academic character may yet have considerable significance in problems of technical interest.

To begin with it is evident that some economy would be effected if the phenols of coal tar could be utilized in resin formation without a preliminary extraction from tar oils. As a convenient source of such fractions, we have utilized low-temperature tar produced during manufacture of smokeless fuel by carbonization of coal at about 600° C. This modern tar has incidentally yielded interesting results in other directions.

A fraction obtained by a simple distillation of tar over a range of 180–205° C., containing about 45% of phenols is heated with aqueous formaldehyde in the presence of caustic alkali or some other suitable alkaline catalyst. After a time, depending on the catalyst employed, resin sinks to the bottom and leaves a middle aqueous layer and a supernatant oil, the latter containing unreacted neutral oil and uncombined phenols with some soluble resin. The insoluble precipitated resin, after removal of the two upper layers, can be purified by washing with suitable solvents such as benzene or by steam distillation in a vacuum. It can then be utilized in the same way as other heat-hardening resins which it resembles in possessing electrical and physical properties comparable with those of resins prepared from phenol itself or purified *m*-cresol. Certain useful by-products may be obtained by this process. Distillation of the benzene washings leaves a residual resin of Novolak type, which may be employed in spirit-soluble varnishes. A single distillation of the supernatant oil yields an almost colourless distillate with obvious possibilities as a liquid fuel, together with a residue of heat-hardening resin which could be applied for cheap impregnating purposes.

The simplified procedure of resin production direct from a coal-tar fraction may be applied to vertical tars—that is tars produced by carbonizing coal in vertical retorts at 1000°.

It is remarkable that from crude tar materials, resins of such valuable properties are derivable. The explanation is indicated by the three following factors: (1) The varying rates of reaction of individual phenols; (2) their mutual influences in mixtures; (3) the effect of neutral oil as diluent. Experiments have been performed to elucidate these factors.

The time of condensation of a phenol may be estimated by heating it with formaldehyde in presence of catalyst until a permanent turbidity, due to insoluble materials, makes its appearance. By varying the quantity of catalyst, and then plotting condensation time against catalyst concentration, a resinification curve can be obtained. By employing different phenols, curves are obtained which indicate the relative speeds of this series of phenols in presence of any particular catalyst. An extension of the method, in which the phenol remains constant, permits comparison of activities of different catalysts. With trimethylamine, 1:3:5-xylenol and *m*-cresol react much more speedily with formaldehyde

than do any other phenols examined, and this rule holds for any of the catalysts. Therefore, since low-temperature tar fraction, b.p. 180—205°, contains chiefly *o*-, *m*-, and *p*-cresols, there is *a priori* evidence that initial products of condensation of this fraction will consist largely of *m*-cresol resin, which is admitted to possess satisfactory properties. Furthermore, it can be shown that relatively large amounts of such sluggish phenols as, for example, *p*-cresol, are required to affect materially the condensation times of a quick-acting phenol. In addition to this fact, neutral oil from low-temperature tar has an appreciable solvent action for *o*-cresol condensation products, but not for those of other phenols such as phenol itself, *m*-cresol, and 1 : 3 : 5-xylenol. Therefore, it may be concluded that resins from *o*-cresol, which are known to have undesirable slow heat-hardening characteristics, are largely eliminated automatically from the foregoing tar condensations and thus the successful preparation of suitable resins is explained.

The manner in which the varying efficacies and speeds of resinification of phenols are affected by their chemical structures is indicated by the following theoretical considerations.

It is now generally believed that the property of resinification is bound up with formation of mixtures of long chain homologues of high molecular weight. In the case of phenol-formaldehyde resins it is probable that the chains consist of alternating methylene groups and phenyl residues, according to the scheme :

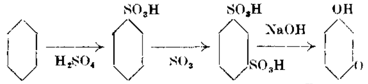
$$R'{\cdot}OH + CH_2O \rightarrow HO{\cdot}R''{\cdot}CH_2OH \text{ (phenolic alcohols)}$$
$$\rightarrow HO{\cdot}R''{\cdot}CH_2{\cdot}R''{\cdot}OH \text{ (dihydroxydiphenylmethanes)}$$
$$\rightarrow HO{\cdot}R''{\cdot}[CH_2{\cdot}R''{\cdot}OH]_x{\cdot}CH_2{\cdot}R''{\cdot}OH \text{ (resins)}$$
$$R = \text{phenyl}$$

The number of isomerides possible according to the *o*- and *p*-law of substitution for specific values of x should partly determine the efficacy of resinification possessed by a phenol. Now *p*-cresol gives only one mono-alcohol, one diphenylmethane derivative ($x = 0$), and only one derivative corresponding with any one value of x. Consequently its products might be anticipated to possess unsatisfactory resinous properties and actually crystalline substances are readily isolated from both alkaline and acidic *p*-cresol condensations.

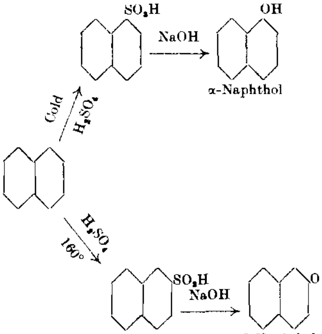
Phenol and 1 : 3 : 5-xylenol theoretically both form two mono-alcohols, three diphenylmethane derivatives, seven derivatives for the value $x = 1$, and twenty-one derivatives for $x = 2$. Consequently these two phenols readily produce substances of highly resinous characteristics, from which only small amounts of crystalline material can be isolated. *m*-Cresol gives even more minute amounts of crystals, together with highly resinous material, and it can be shown that theoretically this phenol should yield three mono-alcohols, six diphenylmethane derivatives, twenty-seven compounds for $x = 1$, and over one hundred compounds for $x = 2$. *o*-Cresol and various xylenol resins have properties between those of phenol and *p*-cresol.

It is of interest to observe that the property of producing satisfactory resins is not necessarily connected with the rate of resinification. Inspection of the resin cation curves described earlier, shows, for example, t *o*-cresol normally reacts much faster than phen although resins from the latter are much more valua and contain fewer crystalline materials. The directi influence of methyl substituents must be invoked any explanation of such phenomena.

The monohydric phenols so far discussed are derivable directly from coal tar. Attention sho now be directed to the more recent utilization of res cinol in the production of resins for gramophone recor The two isomeric α- and β-naphthols have also b suggested for similar resins. These three phenols, dihydric resorcinol and the two monohydric naphth are made synthetically from coal tar products, the fi from benzene through its disulphonic acid and the t latter from naphthalene through its monosulpho acids.



Resorcino



Acetone-formaldehyde resins.—During our ear experiments acetone was used as solvent and diluent phenol-formaldehyde condensations, and thence att tion was drawn to the interaction of acetone itself w formaldehyde. The results form a striking exam of the manner in which an important research may a from an apparently trivial observation in anot investigation. The condensation of these two cheap simple substances has received desultory notice fr various investigators since 1890, when anhydroenn heptitol, now used as a basis for explosives, was p pared by Tollens and collaborators. The simp condensation product, γ-ketobutanol or monometh lacetone was described in 1906.

$$CH_3{\cdot}CO{\cdot}CH_3 + CH_2O \rightarrow CH_3{\cdot}CO{\cdot}CH_2{\cdot}CH_2OH$$

It is a limpid liquid which has the remarkable prope of polymerizing spontaneously to a highly visc

colourless syrup. Recent patent literature describes the preparation of related compounds in which two or more molecules of formaldehyde combine with one of acetone.

Condensation is carried out in presence of alkali, which, when in small amount, induces formation of a colourless water soluble liquid resembling glycerol. When heated *in vacuo* this syrup gives a colourless distillate which polymerizes to a vitreous resin, and leaves *a residue of soluble resin which may be utilized* as a varnish. The hard glassy resin obtained by irreversible chemical change is colourless, but becomes only slightly yellow on heating: it can be turned on the lathe. The colourless distillate from which it is prepared is found to be a complex mixture of substances and not pure γ-ketobutanol.

Another interesting product is obtainable from this distillate. By treatment with suitable catalysts such as iodine, and subsequent heating *in vacuo*, a distillate results which rapidly polymerizes to a pale coloured resin with elastic properties, so that it may be termed an "elastic glass".

Hydrocarbon-formaldehyde resins.—Another class of resins not yet developed commercially to any great extent arises from condensations of aromatic hydrocarbons with formaldehyde, generally in presence of strong sulphuric acid. The coal-tar hydrocarbons, naphthalene, xylene, toluene, and even benzene, may be utilized in this manner to produce resins of Group II type, soluble in benzene, acetone or solvent naphtha. Their scope would appear to lie in varnish or lacquer industries.

An interesting product is that derived by condensation of acenaphthene with formaldehyde in acetic acid as solvent, in presence of sulphuric acid. A yellowish resin is deposited which after washing and drying is obtained as an amorphous powder, yielding resinous films from suitable solvents.

It is of theoretical significance that 4-chloroacenaphthene yields a similar resin, whereas the 4 : 5-dichloro-derivative does not. The importance of free *para*-positions is accordingly indicated.

Aromatic amine-formaldehyde resins.—Condensation of aromatic amines such as aniline with formaldehyde illustrates a class of heat-hardening resin which is now being developed industrially for the production of laminated materials for electrical purposes. Amorphous materials produced from these condensations have long been known, but only in recent years has their commercial exploitation been found practicable. A related resin is obtained from toluene-*p*-sulphonamide and formaldehyde which is light in colour and has plasticizing properties.

Resins formed by polymerization.—The products so far described are of the type known as condensation resins, *that is to say, they are formed by combination* of two dissimilar substances with elimination of a third compound, generally water, although the final stages of conversion by heat are generally attributed to polymerization.

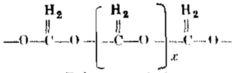
Polymerization may be defined as the union of similar molecules to produce compounds of increased molecular weight, but of the same empirical formula. Possibly the simplest, and at the same time, one of the most striking examples of this phenomenon, is shown in the transformation by heating of acetylene (gas) into benzene (liquid):

$$3C_2H_2 \longrightarrow C_6H_6$$

or

Acetylene Benzene

Although not essential, the presence of "unsaturated" bonds frequently leads to polymerization. Thus aliphatic aldehydes when treated with caustic alkalis yield a well-known but little exploited class of resin by virtue of the inherent power of polymerization contained in the aldehydic group: —CH : O. This effect is well marked in the case of formaldehyde which, by treatment with acid, can be produced in a variety of solid white but non-resinous polymerides, going under the names paraformaldehyde, *trioxymethylene*, *polyoxymethylene*, etc. Polyoxymethylene possesses a structure of the type:



Polyoxymethylene

derived by linkage of $H_2C : O$ groups through oxygen.

The commonest unsaturated bond is the ethylenic or *double bond, which is the important factor in the preparation* of vinyl, styrene, acrolein, coumarone, and indene resins.

The vinyl group, which is the basis of several types of resins, consists of the ethylenic residue: $CH_2 = CH$—. Its derivatives are commonly prepared by the action of a catalyst (frequently a mercury salt) on mixtures of acetylene with other compounds:

$$CH \equiv CH + CH_3{\cdot}COOH \longrightarrow CH_2 = CH{\cdot}O{\cdot}CO{\cdot}CH_3$$

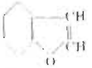
Acetylene Acetic acid Vinyl acetate

Vinyl acetate and chloroacetate are common starting points for resins, and their polymerization can be performed in presence of catalysts of peroxide type such as benzoyl peroxide or sodium perborate. The resulting resins, which fall into Group II, are colourless, and can be produced in large blocks free from bubbles. Their water absorption tends to be high, but has recently been reduced by incorporation of a certain amount of styrene resin. The varnishing of valuable pictures for preservation is an important application of these resins, which appear more suitable for this purpose than other synthetic or natural materials.

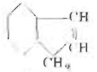
The introduction of aromatic nuclei into the vinyl grouping increases considerably the speed of polymerization to such a degree that styrene, or vinylbenzene ($C_6H_5{\cdot}CH = CH_2$), a hydrocarbon obtained from tar, polymerizes to a solid mass when exposed to light for three weeks. Its resins, which find one application in making fountain-pen reservoirs, can be produced with properties similar to those of vinyl acetate resins.

Another polymerizing compound is acrolein, $CH_2 = CH \cdot CHO$, which is a clear liquid of penetrating odour produced by dehydration of glycerol. It easily polymerizes on heating, or even when left in the light and can give clear yellow inodorous resins.

Coumarone and indene are two substances which while not directly related to vinyl compounds, nevertheless resinify by virtue of their unsaturated groupings.



Coumarone



Indene

They are obtained from coal-tar fractions, boiling over ranges from 168–175° C. and 176–182° C., respectively. By treating them, or the appropriate tar fractions, with strong sulphuric acid, resins are produced which may be almost colourless or nearly black depending on the purity of the starting materials. They are employed in varnishes, in manufacture of linoleum, as constituents of chewing gum, and in construction of hard tennis courts.

Conclusion

This necessarily sketchy outline of the various resins available to-day omits or only barely notices many products of interest.

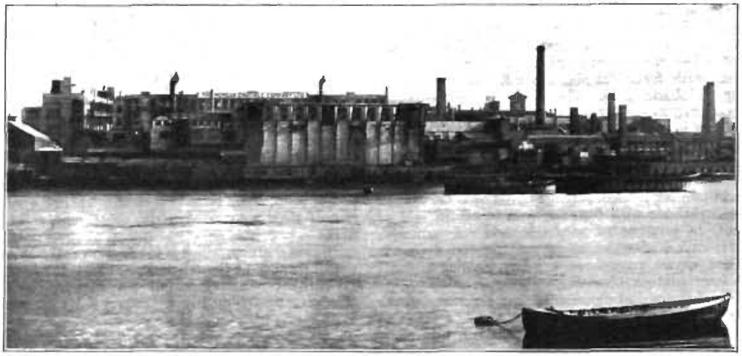
Among these are chlorinated diphenyl resins ("arochlors") having plasticizing properties for cellulose ester finishes. Casein-formaldehyde products, so much in vogue under the popular description "compressed milk" for umbrella handles, buttons, and other fancy articles, hardly fall into the synthetic resin class, and yet they possess many points in common with them. Polymerization products (artificial rubber) of isoprene and butadienes are in a similar category, but space does not permit of their discussion.

THE MORGAN CRUCIBLE CO., LTD.

Ceramics are as old almost as history; no matter to what period we turn, or what part of the world, the potter has always been a craftsman of primary importance. For the last few centuries he has been a good friend to the chemist, and remains so even now, though the potter himself may have given place to the extensive factory and his wheel may have become only one of the many wheels of 20th-century industry. One of the largest producers of ceramics to-day is the Morgan Crucible Co., Ltd., and a visit we paid to the company's works recently was of much interest.

The factory is at Battersea, as anyone who knows this part of the Thames will tell, for the buildings take up some hundreds of yards of the riverside, and one building, with its cement façade and steel arms stretching out over the river, particularly holds the attention. This was where our tour of the works began, for it is in this building that the raw materials are received and put through preliminary treatment. Barges come up to the building with plumbago from Madagascar and Ceylon, kaolin from the West of England, and bauxitic clays and siliceous materials from various parts of this and other countries. These raw materials are taken to the top of the building and shot into huge storage bins. Subsequently they are taken from these bins to the screening and grading machines, and to grinding machines, which may be of the edge-runner or ball mill type according to the type of material being dealt with. Much attention is given to the materials intended for white pottery. A small particle of a ferrous ore in the raw material will cause discoloration of the finished article. Such particles are therefore removed in the early stages of manufacture, and we watched the fine materials passing on a belt underneath three revolving magnets which pick up the iron particles and throw them to one side.

The process by which the materials are blended is o



Riverside View of the Works of Morgan Crucible Co., Ltd.

ie interest. Having been ground, cleaned and graded y are held in large hoppers. A carrier car runs on a ck beneath the hoppers, and stopping beneath the of them, the operator sets an indicator to the centage of the particular ingredient required in the d batch, pulls a lever, and the necessary amount falls the carrier. This then proceeds to the next hopper, l the process is repeated until the batch is made up, en it is elevated to the mixing machines, in which it churned up with water and eventually thrown out in form of plastic lumps of clay. These lumps are put o an extrusion press, and the extruded cylinder is t into convenient lengths for storage, which is necessary the "maturing" of the clay, a process in which it velops plasticity or "workability." The storage room s a humid atmosphere, and is divided into bays to se the clays of various compositions.

Eventually the clay is taken on trolleys to the building which the various ceramic articles are made. The ilding is of recent construction and has large windows erlooking the river, and, in the summer at least, it rmed a very pleasant workroom. On the several ors of the building we were able to see hundreds of fferent ceramic articles being fashioned. On the first or ordinary crucibles were being made *e.g.*, the Battersea Round" which is known to assayers all er the world. For simple articles such as these the old ethod of "throwing" on a potter's wheel is still used th some refinements. On other floors extrusion esses were at work turning out tubing of dimensions rying from those of the thermo-couple insulators tubing of an inch or more bore used for such purposes combustion tubes in steel analysis. The company so manufactures articles of silicon carbide and clay, hilst its plumbago ware is of course well known. It as a matter of some surprise to us to see the precision ith which various ceramic articles were being made. here was, for example, the case with which pyrometer ibes were being sealed and aligned, whilst in another om tubes intended for heating units were having ıreads for the winding coils carefully cut by machine.

In our passage through the works various furnaces ere seen in which the products are fired. Some of these ırnaces are fired by oil, others by producer gas made on ıe spot, and others by coke. Before firing, the clay rticles always pass through a drying process, and the ot gases from the furnace are in some cases used to ccelerate the drying. The furnaces themselves are all yrometrically controlled.

The last part of our visit led through the storage epartment, where every variety of ceramic product kept ready for despatch. Morgan furnace hearths, ıuffle-kilns, boiler settings, combustion chambers are rell known. Here also were all types of crucibles, ipes, closed tubes, bricks, tiles, etc. Of the larger eramic articles retorts are made for metallurgical ork up to $1\frac{1}{2}$ tons capacity. The glazing of some of hese articles is of great importance. This is especially o with articles of plumbago which soon becomes xidized. An "anti-perishing" plumbago composition as therefore been developed which, if the glaze becomes hipped, automatically glazes over again during heating.

One is perhaps apt to think of the ceramic manufacturer in terms of the old potter. Our visit impressed us with the high pitch of organization, the careful control, and the precision with which are prepared the ceramic articles used in so many industries to-day.

SOCIETY OF CHEMICAL INDUSTRY

OFFICIAL NOTICE

Mr. H. Raymond Feeny of the Liverpool Office of Imperial Chemical Industries, Ltd., is about to take up a position on the London staff of the company and has consequently relinquished his office of Hon. Secretary of the Liverpool Section of the Society.

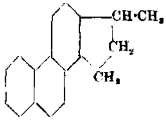
The new Hon. Secretary is Mr. J. S. Towers of J. W. Towers & Co., Ltd., Widnes, where all correspondence henceforward should be addressed.

CORRESPONDENCE

DEHYDROGENATION OF CHOLESTEROL

SIR,—I think the above subject of the discussion with Mr. J. W. Cook (CHEM. & IND., July 21, 1933, p. 603) is interesting enough for making a few remarks, although a fuller account of the syntheses in question has even now been submitted by Mr. H. Hillemann and myself to the *Berichte*.

The identity of 1 : 2-*cyclo*pentenophenanthrene ($C_{17}H_{14}$) with Diels' hydrocarbon ($C_{18}H_{16}$ or $C_{17}H_{14}$?) has not yet been established. It is rather disagreeable for the solution of our problem that also the γ-methyl-1 : 2-*cyclo*pentenophenanthrene is very similar to the preparations obtained according to Diels. The following table contains also Cook and Hewett's results (see Ruzicka, Goldberg, and Thomann, *Helv. Chim. Acta*, 1933, 16, 816).



(Cook and Hewett's hydrocarbon ... ... = A
Hillemann and Bergmann's ... ... = B
Hydrocarbon, obtained according to Diels... = C)

Compound	A m.p.	B m.p.	C* m.p.	Mixed A and C m.p.	Mixed B and C m.p.
Hydrocarbon	185°	125°—127°	123°—124°	132°—142°	120°—124°
Picrate ..	128°—134·5°	130°—131°	120°—122°	120°—126°	125°—128°

* Cook's newest preparation of Diels' hydrocarbon had m.p. 131°—133° (*after sintering 129°*).

I consider that the best method for deciding the problem in question will be a physical comparison of all the hydrocarbons; we hope to present our results referring to this in a very short time. I may add that I by no means say that Cook and Hewett may not be right.

I am, Sir, etc.
ERNST BERGMANN

London
July 29, 1933

PERSONAL AND OTHER ITEMS

The University of London has awarded the degree of Ph.D. to the following: (chemistry) H. Barron, E. J. Boorman, J. F. Danielli, E. P. Davey, G. W. Ferguson, D. C. Garratt, J. B. Harding, E. F. Hartree, E. C. E. Hunter, B. A. S. Kent, G. D. Lefcaditis, G. Macdougall, E. M. Meade, J. G. F. Miller, J. L. Moilliet, B. Nandi, K. S. Nargund, J. Powney, G. J. Pritchard, H. N. Rydon, L. D. Shah, A. B. M. S. Shaikh, Evelyn M. Waldron, N. J. H. Wallis, J. M. Wright, G. W. Himus, E. T. Wilkins, and Beatrice M. Wilson: (chemical engineering) R. R. Hattiangadi; (chemical technology) W. H. Wheeler: (electrochemistry) A. G. Quarrell: (biochemistry) V. H. Chambers and S. Kasinathan: (agricultural chemistry) J. G. Shrikhande.

The following are included in staff appointments which have been made recently at King's College, University of London: Mr. C. S. Salmon, M.Sc., senior lecturer in chemistry; Mr. D. W. G. Style, B.Sc., Ph.D., assistant lecturer in chemistry; Mr. J. H. Hewitt, D.Sc., Ph.D., senior lecturer in physiology.

Lt.-Col. K. G. Maxwell has been appointed manager of publicity of Metropolitan-Vickers Electrical Co., Ltd. Colonel Maxwell has done a considerable amount of work on insulating materials. He has worked as a member of the British Standards Institute Technical Committee on insulating materials, and has been a member of several sub-committees dealing particularly with insulating oils and synthetic resins. On June 28 last he read a paper on "Plastics in the Electrical Industry" at the Science Museum, South Kensington.

The Academic Registrar of London University states that the appointment of Prof. G. W. Florey to the Sir William Dunn Chair of Pathology, mentioned in the JOURNAL of August 4, was announced in error.

Croydon Mouldrite, Ltd.

A development of considerable importance in the plastics industry is announced by Croydon Mouldrite, Ltd., which states that arrangements have been completed between itself and Imperial Chemical Industries, Ltd., whereby the resources, experience, and services of both organizations in the moulding powder and similar fields are now available to the plastics and similar trades through Croydon Mouldrite, Ltd.

British Trade Marks Law

The Association of British Chemical Manufacturers has recently published the memorandum which was drawn up by a Trade Mark Committee representative of the chemical industry and used as a basis of evidence before the Board of Trade Committee on British Trade Mark Law and Practice. It can be obtained from the Association, price 1s., and will be found of much interest by all those concerned with the manufacture or marketing of goods which bear trade marks. The committee responsible for the memorandum included Dr. W. Cullen as the Society's representative, and Dr. L. H. Lampitt as the representative of the Society of Public Analysts.

With regard to assignment the committee recommends in the memorandum that suitable amendments should be made in the existing law so that a registered trade mark which has not been associated, or is no longer associated, with goods, should be freely assigna... without reference to goodwill other than that intrin... value which it may possess; so that a registered tra... mark should be assignable with the goodwill in th... particular goods upon which it has been used; and ... that a parent company and its subsidiaries should ... allowed to use in common a mark registered by t... parent company.

It is suggested also that some guidance might wi... advantage be given to the Registrar in the matter ... "descriptiveness," as it is not always easy to see wh... some marks are held to be descriptive whilst others ar... allowed. On the question of appeals it is suggeste... that for a number of purposes the new Appeals Tribuna... should be substituted for the Board of Trade. Sugge... tions are also made with regard to pirating of trad... marks, classification and costs, whilst a proposal i... put forward for a British Empire Trade Marks Con... vention formed on lines similar to the Internationa... Bureau at Berne, to ensure the protection of mark... throughout the Empire.

Salters' Institute of Industrial Chemistry

The Salters' Institute of Industrial Chemistry ha... awarded fellowships for 1933—34 to N. S. Kelland (St John's College, Oxford), J. D. Rose (Jesus College Oxford), F. C. Storrs (University College, London), an... C. W. Woolgar (King's College, London). In additio... the fellowships held by S. C. Britton (Pembroke College Cambridge), E. H. T. Hoblyn (Imperial College, London)... G. Pearce (University of Birmingham), and P. C. Youn... (Trinity College, Cambridge), have been renewed.

The Salters' Institute has also awarded 110 grants-in... aid to young men and women employed in chemica... works, to facilitate their further studies.

Business Administration

The Department of Business Administration of th... London School of Economics and Political Science London University, has just completed its second yea... of working and the complete success of the department'... work is illustrated by the fact that there is a gratifyin... demand from business for men who have been trained The department is now embarking on a "Universit... Scheme" in which some 10 well-known firms ar... prepared to offer definite appointments to candidate... selected by them and approved by the department o... condition that they take the specialized business course which lasts for an academic year.

Students who attended the 1931—32 session of th... department have since obtained posts with Imperia... Chemical Industries, Ltd., British Xylonite Co., Mon... Nickel Co., Ltd., and other well-known firms. ... prospectus of the scheme of study for the 1933—3... session, which gives also much interesting informatio... about the department's history and aims, can b... obtained from Mr. Jules Menken, head of the depart... ment, 11, Clement's Inn Passage, London, W.C.2.

The London Group of the Industrial Administratio... Students' Union, which is sponsored by the Industria... Administration Institute, has arranged a series of monthl... lectures, beginning in September this year and continuin... until May, 1934. The lecturers include Major N. J Batley, head of the commercial research department o...

Imperial Chemical Industries, Ltd., Mr. G. Still, superintendent of the production control department of the Associated Equipment Co., Ltd., Mr. G. S. W. Marlow, secretary of the Faraday Society, and Cmdr. H. S. H. Ellis, head of the advertising department of Imperial Chemical Industries, Ltd. Full particulars can be obtained from the honorary secretary of the Union, Mr. B. W. Galvin Wright, Imperial Chemical House, Millbank, S.W.1.

Association of Technologists of the River Plate

The Argentine has within its far-flung boundaries abundant supplies of natural wealth. During the last 20 years, mainly as the result of the stimulus given by the war, the exploitation of this wealth has been greatly developed. More recently, partly owing to protective tariffs, the number of industries which have sprung up has increased enormously, bringing in its train the corresponding influx of technical men from abroad.

The newly formed Association of Technologists of the River Plate aims at providing facilities for English speaking technical men to get together for the interchange of ideas relating to industry. The first meeting was held at the English Club, Buenos Aires, on June 27, when the following officers were elected: *President:* L. W. Migotti, M.I.E.E.: *Vice-Presidents:* J. C. Ford, J. Dick: *Chairman:* W. Lawson Hurdman, M.Sc., A.I.C.: *Hon. Secretary:* M. Martin Charap, B.Sc., F.I.C.: *Hon. Treasurer:* H. W. Ritter, B.Sc., A.I.C.: *Committee:* L. W. Cutler, B.Sc., A.I.C., B.Homer, and N. J. Bluman.

During his inaugural address, the president spoke on "Research and Industrial Development." He gave a general survey of research as applied to industry and this was supplemented by examples from specific industries. He added that in the Argentine or any other new country research was of the utmost importance and that its practice should be encouraged by government and industrialists alike. Finally, he stated that the discoveries of the present century indicated that we were moving forward at a pace surpassing all previous records and he trusted that mankind would be worthy of its place in this wonderful age.

New Aluminium Alloys

A number of new alloys of aluminium with notable properties are being manufactured by the I. G. Farbenindustrie A.-G., Bitterfeld, and by the Vereinigte Leicht-Metallwerke G.m.b.H., Bonn. Among these are Hydronalium (7—9% Mg, small amounts of Si and Mn), which is resistant to soda and soap, and an alloy containing 9·5%—7·5% of magnesium, 0·2% of silicon, and 0·2%–0·6% of manganese, which is also resistant to corrosion. Mangal contains 1·5% of manganese, Pantal contains 0·8—2% of magnesium, 0·4%—1·4% of manganese, 0·5%—1·0% silicon, and 0·3% of titanium, while a third alloy, Bondur, consists of aluminium with 4·2% of copper, 0·3—0·6% of manganese, and 0·5%—0·9% of magnesium. Bondur is not resistant to sea water. These new alloys are stated to be superior to magnalium in their resistance to corrosion, and have also good mechanical properties (Chemiker Ztg.).

MARKET REPORT

This Market Report is compiled from special information received from the manufacturers concerned.

Unless otherwise stated, the prices quoted below cover fair quantities net and naked at sellers' works.

The following alterations in prices are reported since the publication of the last Market Report (cf. **Chem. & Ind.**, Aug. 11, 1933, p. 663).

GENERAL HEAVY CHEMICALS

Acid, Chromic.—10½d. per lb., less 2½%, d/d U.K.
Chrometan.—Crystals, 3¼d. per lb.; Liquor, £19 10s. per ton d/d U.K.
Chromium Oxide.—10½d. per lb., according to quantity, d/d U.K.

WOOD DISTILLATION PRODUCTS

Acetate of Lime.—Brown, £8 15s.—£9 per ton. Grey, £14—£16 per ton. Liquor, Brown, 30° Tw., 6d. per gal.
Wood Naphtha.—Miscible, 3s.—4s. *per gal. Solvent*, 3s. 9d.—4s. 9d. per gal.
Wood Tar.—£2 10s.—£6 per ton.

PATENT LIST

The following is a list of complete specifications of chemical interest which are open for inspection under Section 91 (4) (a) of the Patent Acts. Printed copies are not available, but photographic copies may be obtained at a charge of 8d. per page (minimum 1s.) from the Patent Office, Chancery Lane, W.C.2.

I. 542 (1933). Ges. f. Linde's Eismaschinen A.-G. Rectification processes and apparatus.

760—7 (1933). Carbo-Norit-Union Verwaltungs Ges. Purifying liquids by means of pulverulent or fine-grained adsorptive substances.

2534 (1933). Fibroplast Ges. Water-expelling presses.

2783 (1933). *Soc. Indus. d'Appl. Electriques. See* XI.

II. 2579 (1933). Deneke. *See* VII.

III 163 (1933). Carbide & Carbon Chemicals Corp. Polymerizing vinyl compounds.

2525—6 (1933). I. G. Farbenind. Manufacture of quinoline derivatives.

IV. 2195 (1933). Deuts. Hydrierwerke. Manufacture of substantive dyestuffs.

2299 (1933). Durand & Huguenin A.-G. Manufacture of easily soluble ester-salts of leuco-vat-dyestuffs.

2653 (1933). I. G. Farbenind. Manufacture of dyestuffs.

21,141 (1933). I. G. Farbenind. *See* XXI.

V. 1675 (1933). Soc. le Pratique. Disinfecting and cleaning fabrics.

2591 (1933). Brit. Celanese, Ltd. Manufacture of cellulose derivatives.

VI. 2178 (1933). Smith, Drum & Co. Dyeing machine.

VII. 29,480 (1932). Kali-Forschungs-Anstalt. Production of potassium nitrate.

36,013 (1932). Gewerkschaft Gevenich, Englert, and Becker. Obtaining blanc fixe.

1924—5 (1933). Goldschmidt A.-G. Production of monobasic aluminium sulphite.

2579 (1933). Deneke. Obtaining sulphur from spent gas purification masses.

2747 (1933). Grasselli Chem. Co. Manufacture of barium fluosilicate.

VIII. 1805 (1933). *N. V. Philips' Gloeilampenfabr.* Winning of highly refractory carbides.

IX. 12,609 (1932). Straba Strassenbaubedarfs-A.-G. *Producing hydraulic building materials.*

2433 (1933). Leichtbaustoff-Ges. *Production of porous masses and objects.*

X. 24,333 (1932). Aluminum Colors, Inc. *Treatment of surfaces of aluminium or aluminium alloy articles.*

2714 (1933). Roessler & Hasslacher Chem. Co. *Case-hardening of steel etc.*

XI. 2317 (1933). Internat. Gen. Electric Co. *Impregnating compounds for insulating purposes.*

2535 (1933). Internat. Gen. Electric Co. *Insulating materials.*

2783 (1933). Soc. Indus. d'Appl. Electriques. *Electrostatic precipitation apparatus.*

XIII. 36,013 (1932). Gewerkschaft Gevenich, Englert, and Becker. *See* VII.

163 (1933). Carbide & Carbon Chemicals Corp. *See* III.

1902 (1933). Furman. *Coating and impregnating.*

XIV. 27,934 (1932). Goodyear Tire & Rubber Co. *Vulcanization of rubber.*

XVIII. 2793 (1933). Denys. *Producing and accelerating the alcoholic fermentation of distillery musts.*

2875 (1933). Industrikemiska Aktieb. *Manufacture of yeast.*

XIX. 2524 (1933). Commanditaire Venn. onder Sippesteijn. *Preparation of cattle food.*

XXI. 21,141 (1933). I. G. Farbenind. *Sensitization of photographic silver halide emulsions and manufacture of a sensitizing dye therefor.*

XXIII. 766—7 (1933). Carbo-Norit-Union Verwaltungs-Ges. *See* I.

GENERAL NOTES

Official Trade Intelligence

The Department of Overseas Trade (Development and Intelligence), 35, Old Queen Street, London, S.W.1, has received the following inquiries for British goods. British firms may obtain further information by applying to the Department and stating the specific number. *Australia:* Vegetable parchment (140). *Brazil:* Tinplate (156). *British India:* Caustic soda cells (A.Y. 11,928). *Italy:* Paint, varnish, etc. (B.Y. 7626). *Palestine:* Acid oils (149). *South Africa:* Copper and steel locomotive boiler plates (G.Y. 12,845); Mixed and paste paints, paint ingredients, etc. (B.Y. 7634). *Switzerland:* Pharmaceutical chemicals (155).

Fertilizer Prices

Imperial Chemical Industries, Ltd. has announced prices for neutral sulphate of ammonia, 20·6% nitrogen, for delivery to farmer's nearest station carriage paid in 6 ton lots, as follows: September £6 15s., October £6 15s., November £6 17s. 6d., December £7, January £7 2s. 6d., February June £7 5s. per ton.

The price of nitro-chalk, basis 15·5% nitrogen, for delivery up to June, 1934, in 6 ton lots, carriage paid to farmer's nearest station, is unchanged at £7 5s. per ton.

The price for British nitrate of soda, basis 16% nitrogen, for delivery up to June, 1934, in 6 ton lots, carriage paid to farmer's nearest station is £7 5s. per ton.

New I.C.I. Dyestuffs

Three new dyestuffs have been announced by Imperial Chemical Industries, Ltd. The first two are additions to the Durindone range of colours, Durindone Scarlet 2B Paste and Durindone Scarlet 3B Paste. These are well suited to the dyeing of all types of cotton material, and possess excellent fastness to washing, boiling, bleaching, etc. They are suitable also for the direct printing of cotton, viscose, and silk, and give good results with a potash-Formosal recipe.

Monolite Red 4RS is offered in paste and powder forms, and is a pigment similar in shade, as a printing-ink colour, to the calcium lake of Monolite Rubine 2BS Paste, but possesses a cleaner undertone. It possesses good fastness to light, lime, alkali, and water, and is eminently suited to the manufacture of printing inks, enamels, paints, and distempers. The good fastness to alkali makes it of particular interest for the manufacture of inks for soap-wrapper printing and exhibition carton boards, where the ink has to withstand long exposure to light in the presence of alkali contained in the card substance. It will find use also for wallpaper and linoleum.

The Barber Mixing Jet

Although most chemical processes and many chemico-physical ones involve mixing in one form or another, the methods still in use are often somewhat crude and cumbersome, with consequent waste and inefficiency. An apparatus that will therefore appeal to many manufacturers is the Barber Mixing Jet, the principle of operation of which is to maintain one fluid in the form of a film, whilst the other is introduced into it in the form of jets. This process ensures great intimacy of the two materials being mixed, and is independent of such factors as viscosity, temperature, and specific gravity.

This apparatus realizes the possibility of converting *discontinuous processes into continuous ones*, and, by reason of its large capacity, offers enormous economies in space and time. Its capacity may be realized from the fact that a jet with a 2-in. orifice will pass up to 1000 gal. per hour (in accordance with the viscosities of the fluids), giving absolutely uniform results under perfect control. The pressures used are almost invariably under 15 lb. per square inch and usually about 10 lb. per square inch. More than two materials may be mixed by using jets in series, and processes may be run in continuous sequence by a suitable arrangement of apparatus.

There are obviously many fields of usefulness for this apparatus, amongst which those more readily presenting themselves are the mixing of reacting chemicals, the "blowing" of oils, the sterilizing of water etc., the humidifying and drying of air, and the washing of gases, dust removal, etc.

The Barber jet is produced by Robert Jenkins & Co., Ltd. of Rotherham, from whom a descriptive leaflet can be obtained.

PUBLICATIONS RECEIVED

MODERN ALCHEMY. By W. A. Noyes and W. A. Noyes, Jr. Pp. ix + 207. Springfield, Illinois: C. C. Thomas; London: Baillière, Tindall & Cox. 1932. $2.00. 17s. 6d.

REPORT OF THE FOOD INVESTIGATION BOARD FOR THE YEAR 1932. *Department of Scientific and Industrial* Research. Pp. x + 304. London: H.M. Stationery Office, 1933. 5s.